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IN THE INTERNATIONAL BUREAU OF WIPO

Applicant:	DEKA Products Limited Partnership
Int'l Application No:	PCT/US04/024335
Int'l Filing Date:	28 July 2004
Title of Invention:	Systems and Methods for Distributed Utilities
Atty Docket:	1062/E19WO
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VIA FEDERAL EXPRESS

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In connection with the Communication Concerning Priority Document issued by the European Patent Office dated 7 August 2006 (copy enclosed), I hereby certify that the following document is being forwarded via Federal Express Delivery to the International Bureau of WIPO, PCT Receiving Office Section, 34, chemin des Colombettes, 1211 Geneva 20, Switzerland on 8 September 2006.

Enclosed document:

Priority document 60/518,782 dated 10 November 2003

September 12, 2006

Respectfully submitted,

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Date 07-08-2006

Reference	Application No./Patent No.
PJF02138EP	04779401.1 - 1249 PCT/US2004024335
Applicant/Proprietor	
DEKA PRODUCTS LIMITED PARTNERSHIP	

Communication concerning the priority document US60/518782 dated 10.11.03

With respect to the filing of the certified priority document(s) for the above-mentioned European patent application, we would like to inform you as follows:

The International Bureau [IB] has not received the priority document from the PCT Receiving Office [RO] despite the applicant's request under Rule 17.1(b) PCT. Please note that as long as the priority document is missing, substantive examination can only begin, if the patentability of the claimed subject-matter is not dependent on the validity of the priority right. However no European patent will be granted (i.e. no communication "Decision to grant a European patent pursuant to Article 97(2) EPC" [EPO Form 2006] will be dispatched to the applicant) as long as the priority document is not on file.

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August 31, 2006

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APPLICATION NUMBER: ***60/518,782***
FILING DATE: ***November 10, 2003***

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS ***US60/518,782***

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Under Secretary of Commerce for Intellectual Property
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N. Williams

N. WILLIAMS
Certifying Officer

PTO/SB/16 (08-03)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EV 333084430 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
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Additional inventors are being named on the ______ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

Locally Powered Water Distillation System

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

[X] Customer Number: 002101

OR

[ ] Firm or Individual Name					
Address					
Address					
City		State		ZIP	
Country		Telephone		Fax	

ENCLOSED APPLICATION PARTS ***(check all that apply)***

[X] Specification *Number of Pages* 9
[ ] CD(s), Number ______
[X] Drawing(s) *Number of Sheets* 5
[X] Other (specify) Return postcard
[X] Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

[ ] Applicant claims small entity status. See 37 CFR 1.27.
[ ] A check or money order is enclosed to cover the filing fees.
[X] The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 19-4972
[ ] Payment by credit card. Form PTO-2038 is attached.

FILING FEE Amount ($): 160.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[X] No.
[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ______

Respectfully submitted,

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Date 11/10/03

REGISTRATION NO. 37,910
(If appropriate)
Docket Number: 1062/E08

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Practitioner's Docket No. 1062/E08 *PATENT*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Dean Kamen, Kingston Owens

Application No.: Not Assigned
Filed: 11/10/2003
For: Locally Powered Water Distillation System

Group No.: N/A
Examiner: N/A

Mail Stop Provisional Application
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

EXPRESS MAIL CERTIFICATE

"Express Mail" label number EV 333084430 US
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I hereby state that the following *attached* paper or fee

New Provisional Patent Application, including transmittals and documents referenced therein

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. § 1.10, on the date indicated above and is addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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01062/00E08 279524.1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Provisional Patent Application for

LOCALLY POWERED WATER DISTILLATION SYSTEM

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LOCALLY POWERED WATER DISTILLATION SYSTEM

[0001] The present application contains subject matter related to US Provisional Patent Application 60/425,820, filed November 13, 2002, which is incorporated herein by reference.

Technical Field

[0002] The present invention pertains to systems and methods for locally powering water purification systems, and, more particularly, to providing both electric power and heat output from external combustion heat engines to water purification systems.

Background Art

[0003] A dependable source of potable water eludes vast segments of humanity, the Canadian International Development Agency reporting that about 1.2 billion people lack access to safe drinking water. A person must depend, for a supply of clean water, on proximity to uncontaminated natural sources, or must otherwise have access to a dependable common system of publicly treated water, or else dependable supplies of chemical purifying agents or power sources for distillation, none of which are typically available in much of the developing world. Consequently, an integral and reliable source of treating water, whether for medical purposes, for human consumption, or otherwise, that is robust, efficient, and requires only readily available materials is very desirable. As used herein, and in any appended claims, the term 'purifying' refers to reducing substantially the concentration of one or more contaminants to specified levels.

Summary of the Invention

[0004] In accordance with preferred embodiments of the present invention, there is provided a method for removing contaminants from water. The method has a first step of driving an electric generator by means of a thermal cycle engine for generating electrical power capacity, the thermal cycle engine including a burner for combusting a fuel. The method has further steps of employing at least a portion of the electrical power capacity of the electric generator for powering a water purification unit, supplying source water to an input of the water purification unit, and conveying heat output of the thermal cycle

engine for supplying heat to the water purification unit. In a specific embodiment, the water purification unit can be a vapor compression distillation system. In such case the method may additionally have the steps of vaporizing the untreated water; and condensing the vaporized water into a distilled water product.

[0005] In accordance with further embodiments of the invention, the step of conveying heat output may further include transferring heat from an exhaust gas of the burner to source water supplied to the water purification unit, and also heating an enclosure surrounding the water purification unit for reducing thermal losses.

[0006] In accordance with other embodiments of the invention, a method is provided for concentrating contaminants removed from water. The method has steps of:

a. driving an electric generator by means of a thermal cycle engine for generating electrical power capacity, the thermal cycle engine including a burner for combusting a fuel;
b. employing at least a portion of the electrical power capacity of the electric generator for powering a water purification unit;
c. supplying source water to an input of the water purification unit;
d. conveying heat output of the thermal cycle engine for supplying heat to the water purification unit;
e. vaporizing the untreated water; and
f. collecting contaminants removed from the water.

[0007] In accordance with yet further embodiments of the invention, a system is provided for purifying water that has a thermal cycle engine including a burner for combusting a fuel for driving an electric generator to generate electrical power capacity and a water purification unit powered by the electric generator. The system also has an input for receiving source water for purification by the water purification unit and a for conveying heat output of the thermal cycle engine to the water purification. . In a specific embodiment, the water purification unit can be a vapor compression distillation system.

[0008] The thermal cycle engine may be an external combustion engine, such as a Stirling cycle engine, and the exhaust conduit of the system may be a hose for conveying

heated gas from the burner of the thermal cycle engine to the water purification unit. The system may also have a heat exchanger in a path of the source water from the input to the water purification unit.

Brief Description of the Drawings

[0009] The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in which:

Fig. **1** shows the component power unit and water purifier unit in accordance with a preferred embodiment of the present invention;

Fig. **2** is a basic block diagram of a vapor compression water purification unit in accordance with embodiments of the invention;

Fig. **3** is a cross sectional view of a vapor compression water purification unit in accordance with embodiments of the invention;

Fig. **4** is a schematic block diagram of an auxiliary power unit for providing electrical power and heat for water purification in accordance with the present invention; and

Fig. **5** is a schematic overview of an integral power unit/water purification system in accordance with an embodiment of the present invention.

Detailed Description of the Invention

[0010] The systems provided in accordance with embodiments of the present invention has two basic functional components that may be combined within a single integral unit or may be capable of separate operation and coupled as described herein for the purpose of local water purification. Fig. 1 depicts an embodiment of the invention in which a power unit **10** is coupled electrically, via cable **14**, to provide electrical power to a vapor compression water distillation unit **12**, with exhaust gas from the power unit coupled to convey heat to the water distillation unit via an exhaust duct **16**.

[0011] Use of an external combustion engine, such as a Stirling cycle engine, to provide mechanical power for conversion into electrical power by means of a generator is described in detail in US Patent No. 6,536,207 (Kamen et al.), issued March 25, 2003, and incorporated herein by reference.

[0012] Thermal cycle engines are limited, by second law of thermodynamics, to a fractional efficiency, i.e., a Carnot efficiency of $(T_H-T_C)/T_H$, where T_H and T_C are the temperatures of the available heat source and ambient thermal background, respectively. During the compression phase of a heat engine cycle, heat must be exhausted from the system in a manner not entirely reversible, thus there will always be a surfeit of exhaust heat. More significantly, moreover, not all the heat provided during the expansion phase of the heat engine cycle is coupled into the working fluid. Here, too, exhaust heat is generated that may be used advantageously for other purposes. The total heat thermodynamically available (i.e., in gas hotter than the ambient environment) in the burner exhaust is typically on the order of 10% of the total input power. For a power unit delivering on the order of a kilowatt of electrical power, as much as 700 W of heat may be available in an exhaust stream of gas at temperatures in the vicinity of 200°C. In accordance with embodiments of the present invention, the exhaust heat, as well as the electrical power generated by an engine-powered generator, are used in the purification of water for human consumption, thereby advantageously providing an integrated system to which only raw water and a fuel need be provided.

[0013] Moreover, external combustion engines, such as Stirling cycle engines, are capable of providing high thermal efficiency and low emission of pollutants, when such methods are employed as efficient pumping of oxidant (typically, air, and, referred to herein and in any appended claims, without limitation, as "air") through the burner to provide combustion, and the recovery of hot exhaust leaving the heater head. In many applications, air is pre-heated, prior to combustion, nearly to the temperature of the heater head, so as to achieve the stated objectives of thermal efficiency. However, the high temperature of preheated air, desirable for achieving high thermal efficiency, complicates achieving low-emission goals by making it difficult to premix the fuel and air and by requiring large amounts of excess air in order to limit the flame temperature. Technology directed toward overcoming these difficulties in order to achieve efficient and low-emission operation of thermal engines is described, for example, in US Patent No. 6,062,023 (Kerwin, et al.) issued May 16, 2000, and incorporated herein by reference. External combustion engines are, additionally, conducive to the use of a wide variety of fuels, including those most available under particular local circumstances, however the teachings of the present description are not limited to such engines, and internal

combustion engines are also within the scope of the present invention. Internal combustion engines, however, impose difficulties due to the typically polluted nature of the exhausted gases, and external combustion engines are preferably employed.

[0014] Within the scope of the present invention, water purification system **12** may be embodied in various ways. A conceptual flow diagram of a vapor compression distillation unit in accordance with one possible embodiment of the present invention is shown in Figure 2, with liquid flow paths indicated by arrows. In an embodiment of this type, liquid flows through the system from an intake **00** into an exchanger **400** wherein exchanger **400** receives heat from at least one of a plurality of sources including a condenser **200**, a head **300**, and exhaust (not shown) from a power source such as an internal or external combustion engine. Liquid continues flowing past heat exchanger **400** into a sump **500** and into a core **600** in thermal contact with condenser **200**. In the core **600**, the liquid is partially vaporized. From core **600**, the vapor path proceeds into head **300** in communication with a compressor **100**, and from there into condenser **200**. After vapor is condensed, liquid proceeds from condenser **200** through heat exchanger **400**, and finally into an exhaust region **700** and then out as final distilled product.

[0015] Pre-treatment of the liquid to be distilled, typically water in the present application, occurs within intake **00**. Pre-treatment operations may include any or all of gross-filtering, treatment with chemical additives such as polyphosphates or polyaspartates, electrochemical treatment such as with an oscillating magnetic field or an electrical current, degassing, or UV treatment. As mentioned above, in one particular embodiment, a Stirling engine generator which produces essentially pure CO_2 exhaust is used as the power source **800** to power the overall system. In such an embodiment, the exhaust from the Stirling engine may be funneled back to intake **00** and used to acidify the water to be purified as one means of pre-treatment. Such acidification may, for example, reduce any scaling that might otherwise occur in the system.

[0016] A practical embodiment of the vapor compression still of Fig. 2 is shown in the cross-sectional view of Fig. 3. In this embodiment, the motor is located inside the pressure and fluid boundary of the system. This eliminates the need for a sealed shaft penetration of the pressure boundary. In addition, the motor is maintained at a constant temperature by the surrounding saturated steam. Heat generated by the motor is therefore

transferred into the system, reducing the overall heat input required to maintain the temperature. Motor housing **27** contains motor **150** with motor rotor **37** and motor stator **38**, motor bearings **28**, and pump rotor drive shaft **14**. Fixed housing **25** encloses non-rotating valve-plate **33**, and pump rotor **8** having multiple rotor vanes **17**, rotor bearings **16**, and a liquid ring **19**, typically water, that rotates with rotating housing **10**.

[0017] An embodiment of a power unit **10** is shown schematically in Fig. 4. Power unit **10** includes an external combustion engine **101** coupled to a generator **102**. In a preferred embodiment, the external combustion engine **101** is a Stirling cycle engine. The outputs of the Stirling cycle engine **101** during operation include both mechanical energy and residual heat energy. Heat produced in the combustion of a fuel in a burner **104** is applied as an input to the Stirling cycle engine **101**, and partially converted to mechanical energy. The unconverted heat or thermal energy accounts for 65 to 85% of the energy released in the burner **104**. This heat is available to provide heating to the local environment around the APU in two forms: a smaller flow of exhaust gas from the burner **104** and a much larger flow of heat rejected at the cooler **103** of the Stirling engine. The exhaust gases are relatively hot, typically 100 to 300°C, and represent 10 to 20% of the thermal energy produced by the Stirling engine **101**. The cooler rejects 80 to 90% of the thermal energy at 10 to 20°C above the ambient temperature. The heat is rejected to either a flow of water or, more typically, to the air via a radiator **107**. Stirling cycle engine **101** is preferably of a size such that power unit **10** is portable.

[0018] As shown in Figure 4, Stirling engine **101** is powered directly by a heat source such as burner **104**. Burner **104** combusts a fuel to produce hot exhaust gases which are used to drive the Stirling engine **101**. A burner control unit **109** is coupled to the burner **104** and a fuel canister **110**. Burner control unit **109** delivers a fuel from the fuel canister **110** to the burner **104**. The burner controller **109** also delivers a measured amount of air to the burner **104** to advantageously ensure substantially complete combustion. The fuel combusted by burner **104** is preferably a clean burning and commercially available fuel such as propane. A clean burning fuel is a fuel that does not contain large amounts of contaminants, the most important being sulfur. Natural gas, ethane, propane, butane, ethanol, methanol and liquefied petroleum gas ("LPG") are all clean burning fuels when the contaminants are limited to a few percent. One example of a commercially available propane fuel is HD-5, an industry grade defined by the Society of Automotive Engineers

and available from Bernzomatic. In accordance with an embodiment of the invention, and as discussed in more detail below, the Stirling engine **101** and burner **104** provide substantially complete combustion in order to provide high thermal efficiency as well as low emissions. The characteristics of high efficiency and low emissions may advantageously allow use of power unit **10** indoors.

[0019] Generator **102** is coupled to a crankshaft (not shown) of Stirling engine **101**. It should be understood to one of ordinary skill in the art that the term generator encompasses the class of electric machines such as generators wherein mechanical energy is converted to electrical energy or motors wherein electrical energy is converted to mechanical energy. The generator **102** is preferably a permanent magnet brushless motor. A rechargeable battery **113** provides starting power for the power unit **10** as well as direct current ("DC") power to a DC power output **112**. In a further embodiment, APU **10** also advantageously provides alternating current ("AC") power to an AC power output **114**. An inverter **116** is coupled to the battery **113** in order to convert the DC power produced by battery **113** to AC power. In the embodiment shown in Figure 1, the battery **113**, inverter **116** and AC power output **114** are disposed within an enclosure **120**.

[0020] Utilization of the hot exhaust gas generated in the operation of power unit **10** is now described with reference to the schematic depiction of an embodiment of the invention in Fig. **5**. Burner exhaust is directed through a heat conduit **16** into enclosure **504** of water purification unit designated generally by numeral **12**. Heat conduit **16** is preferably a hose that may be plastic or corrugated metal surrounded by insulation, however all means of conveying exhaust heat from power unit **10** to water purification unit **12** are within the scope of the present invention. The exhaust gas, designated by arrow **502**, blows across finned heat exchanger **506**, thereby heating the source water stream **508** as it travels to still evaporator **510**. The hot gas **512** that fills the volume surrounded by insulated enclosure **504** essentially removes all thermal loss from the still system since the gas temperature within the insulated cavity is hotter than surface **514** of the still itself. Thus, there is substantially no heat flow from the still to the ambient environment, and losses on the order of 75 W for a still of 10 gallon/hour capacity are thereby recovered. A microswitch **518** senses the connection of hose **16** coupling hot exhaust to purification unit **12** so that operation of the unit may account for the influx of hot gas.

[0021] In accordance with alternate embodiments of the invention, adding heat to exhaust stream **502** is within the scope of the invention, whether through addition of a post-burner (not shown) or using electrical power for ohmic heating.

[0022] During initial startup of the system, power unit **10** is activated, immediately providing both electrical power and hot exhaust. Warm-up of water purification unit **12** is significantly accelerated since finned heat exchanger **506** is initially below the dew point of the moisture content of the exhaust and since the exhaust is saturated with water as the primary burner combustion product. All the heat of vaporization of this water content is available to heat source water as the water condenses on the fins of the heat exchanger. The heat of vaporization supplements heating of the fins by convection of hot gas within the still cavity. Heating of the fins by convection continues even after the fins reach the dew point of the exhaust.

[0023] In accordance with other embodiments of the present invention, power unit **10** and water purification unit **12** may be further integrated by streaming water from the purification unit through the power unit for cooling purposes. The use of source water for cooling presents problems due to the untreated nature of the water, whereas the product water has a higher heat content and lower cooling value, and requires an added complexity of the system to allow for cooling of the power unit before the purification unit has warmed up to full operating conditions.

[0024] The described embodiments of the invention are intended to be merely exemplary and numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in the appended claims.

Attorney Docket: 1062/E08

LOCALLY POWERED WATER DISTILLATION SYSTEM

Abstract

A system and method for purifying water or for concentrating contaminants. A thermal cycle engine such as an external combustion engine generates electrical power capacity by driving an electric generator. The thermal cycle engine includes a burner for combusting a fuel. At least a portion of the electrical power capacity of the electric generator powers a water purification unit such as a vapor compression distillation unit, to which untreated source water is supplied Heat output of the thermal cycle engine supplies heat to the water purification unit, both for heating the source water and for reducing or eliminating heat losses through the enclosure containing the water purification unit. The source water is vaporized and condensed to form a distilled water product.

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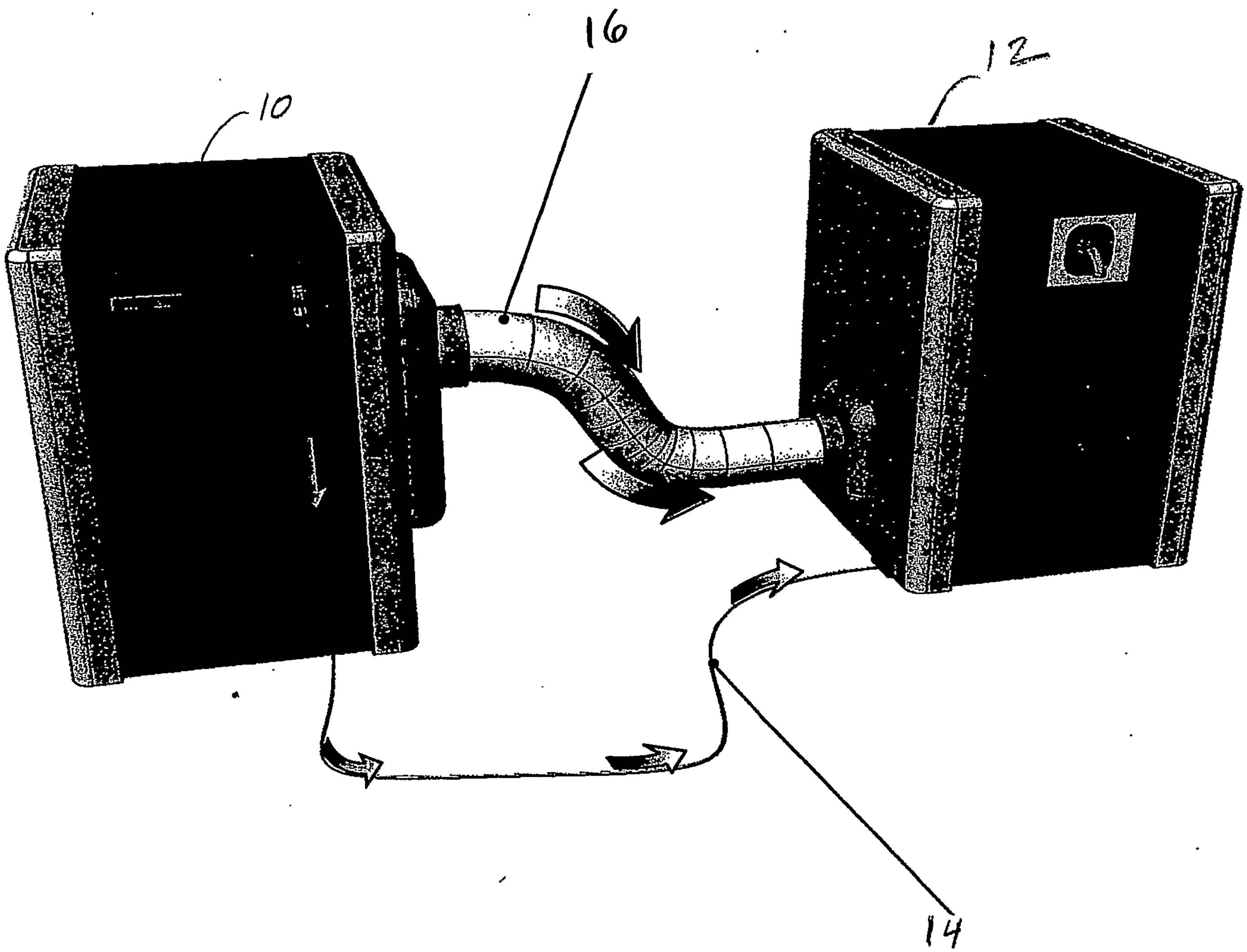

Fig. 1

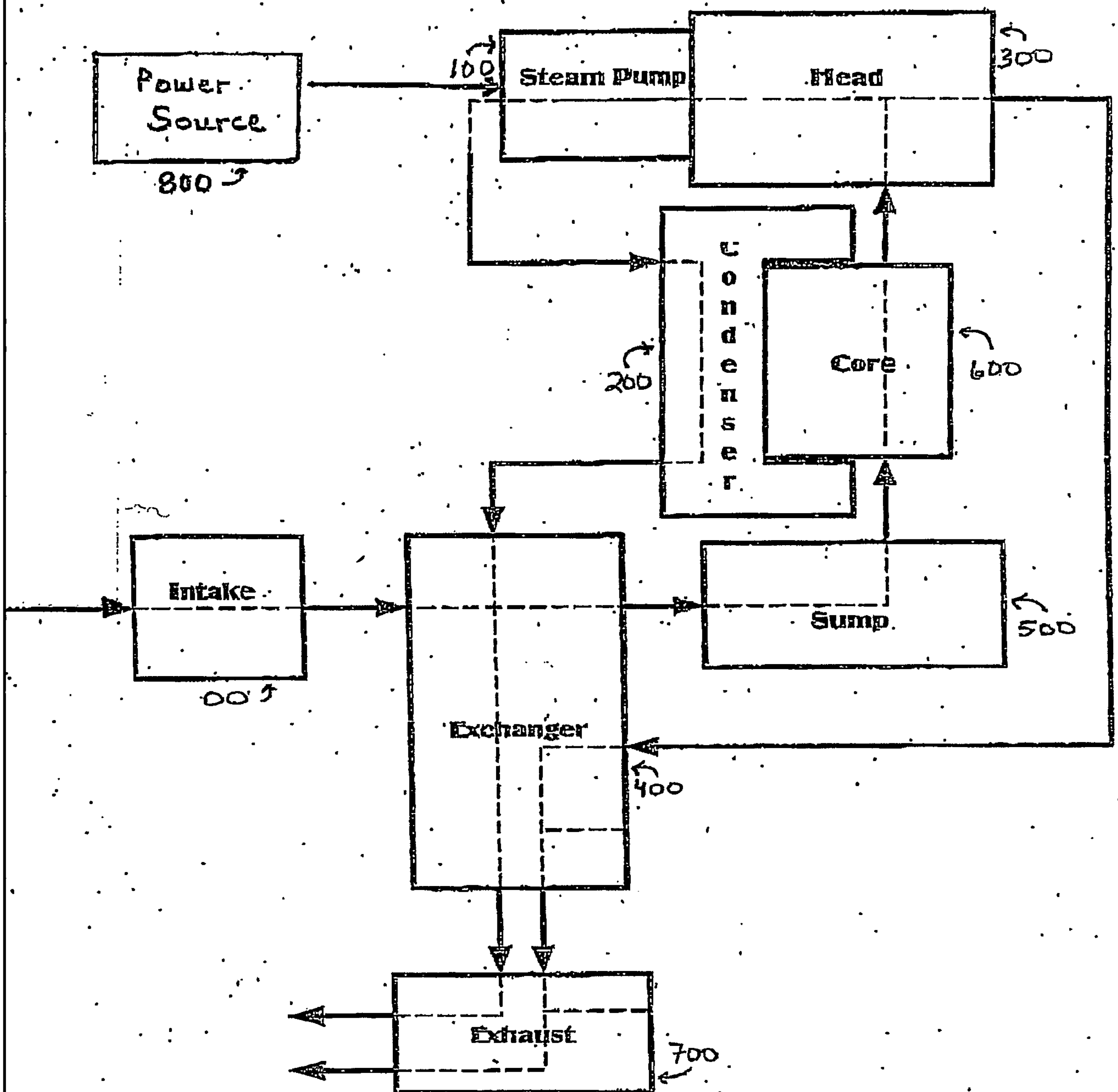
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Fig. 2

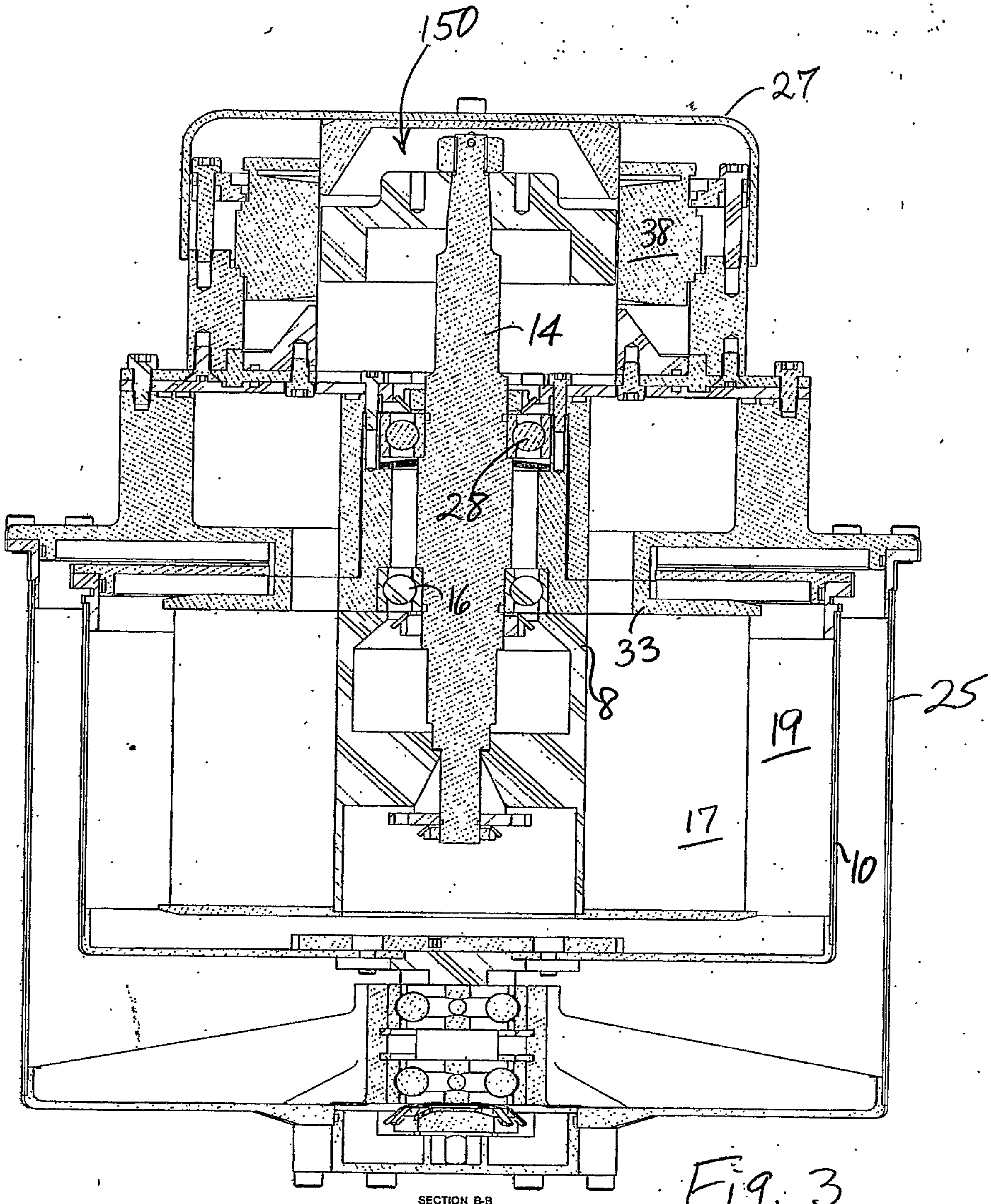

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Fig. 3

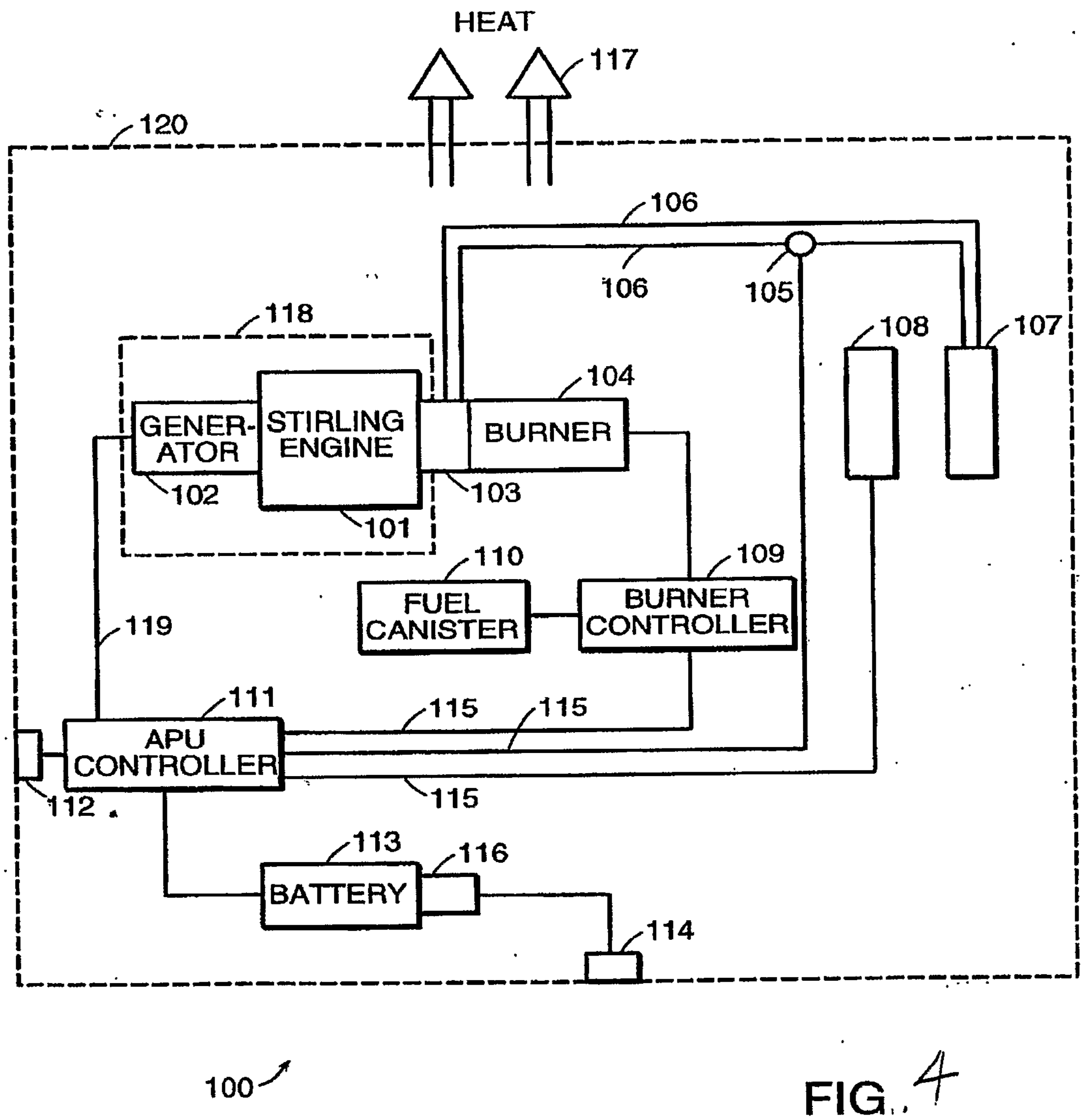
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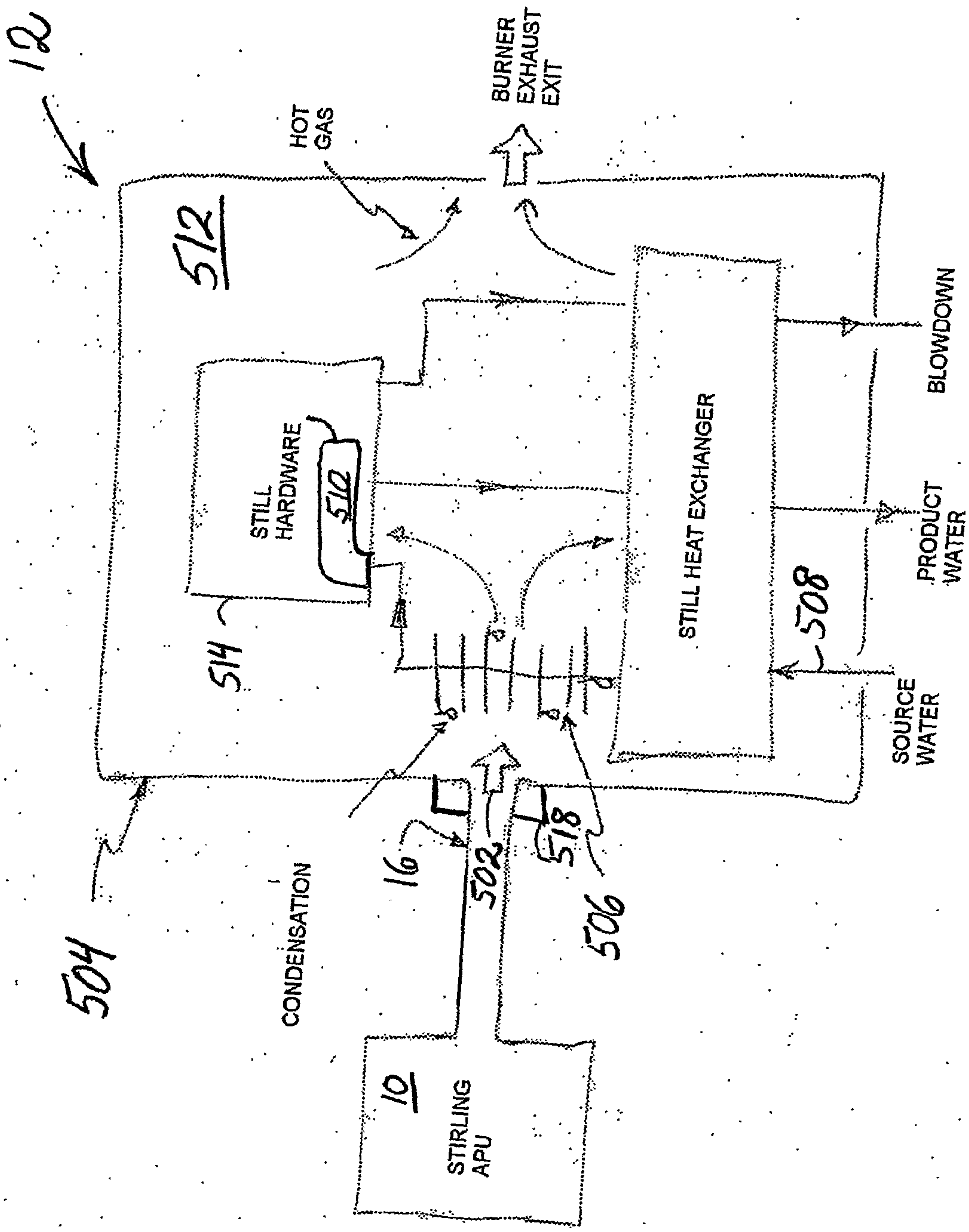
FIG. 4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502
518
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STIRLING APU

Fig. 5

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Correspondence Information

Correspondence Customer Number:: 2101

Application Information

Title Line One:: Locally Powered Water
Title Line Two:: Distillation System
Total Drawing Sheets:: 5
Formal Drawings?:: No
Application Type:: Provisional
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Representative Registration Number:: 37,910